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<p>(21) International Application Number: <b>PCT/GB96/00395</b></p> <p>(22) International Filing Date: 21 February 1996 (21.02.96)</p> <p>(30) Priority Data:</p> <table border="0"> <tr> <td>9503484.9</td> <td>22 February 1995 (22.02.95)</td> <td>GB</td> </tr> <tr> <td>9506045.5</td> <td>24 March 1995 (24.03.95)</td> <td>GB</td> </tr> <tr> <td>9516885.2</td> <td>17 August 1995 (17.08.95)</td> <td>GB</td> </tr> </table> <p>(71) Applicant (for all designated States except US): <b>AXIS BIO-CHEMICALS A/S [NO/NO]; Helgesensgata 30, N-0505 Oslo 5 (NO).</b></p> <p>(71) Applicant (for GB only): <b>COCKBAIN, Julian [GB/GB]; 27 Ladbroke Road, London W11 3PD (GB).</b></p> <p>(72) Inventor; and (75) Inventor/Applicant (for US only): <b>SUNDREHAGEN, Erling [NO/NO]; Axis Biochemicals a/s, Helgesensgata 30, N-0505 Oslo 30 (NO).</b></p> <p>(74) Agents: <b>COCKBAIN, Julian et al.; Frank B. Dehn &amp; Co., 179 Queen Victoria Street, London EC4V 4EL (GB).</b></p>	9503484.9	22 February 1995 (22.02.95)	GB	9506045.5	24 March 1995 (24.03.95)	GB	9516885.2	17 August 1995 (17.08.95)	GB	<p>(81) Designated States: <b>AL, AM, AT, AU, AZ, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).</b></p> <p><b>Published</b> <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i></p>
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(54) Title: <b>CARBOHYDRATE-DEFICIENT TRANSFERRIN ASSAY</b>										
<p>(57) Abstract</p> <p>The invention provides a method of assessment of carbohydrate-deficient transferrin in a transferrin containing body fluid, said method comprising the steps of: i) obtaining a transferrin containing liquid sample of or derived from a said fluid; ii) contacting said sample with a source of iron ions; iii) subsequently contacting said sample with an anionic ion exchange resin at a pH such as to cause carbohydrate-deficient transferrin to be retained by said resin; iv) subsequently contacting said resin with an eluant serving to release carbohydrate-deficient transferrin into the eluate from said resin; v) collecting a volume of said eluate substantially free from tetra- and penta-sialo transferrin; and vi) assessing the transferrin variant content in said volume of eluate. By including at least a proportion of the trisialotransferrin in the eluate, it is possible to use relatively simple assessment techniques such as turbidimetry in the assay.</p>										

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## Carbohydrate-deficient transferrin assay

This invention relates to an assay method for assessing carbohydrate-deficient transferrin (CDT), and to kits and apparatus for performing the assay.

Serum transferrin is a glycoprotein with a molecular weight of about 80kD which comprises a single polypeptide chain with two N-linked polysaccharide chains. These polysaccharide chains are branched and terminate in five antennae with terminal sialic acid residues.

Wong and Regoeczi, in *Int. J. Peptide Res.* 2:241-248(1977), reported that human transferrin was naturally heterogeneous, occurring in variant forms with different levels of sialylation. In fact there appear to be six such variants, the pentasialo, tetrasialo, trisialo, disialo, monosialo and asialo transferrins.

In the normal healthy individual, the tetrasialo variant appears to predominate; however it has been found that the asialo, monosialo, disialo and, to some degree the trisialo variants occur in elevated levels in the blood of alcoholics (see van Eijk et al in *Clin Chim Acta* 132:167-171(1983), Stibler in *Chin Chim* 37:2029-2037(1991) and Stibler et al in "Carbohydrate-deficient transferrin (CDT) in serum as a marker of high alcohol consumption", *Advances in the Biosciences*, (Ed Nordmann et al), Pergamon, 1988, Vol. 71, pages 353-357).

The asialo, monosialo, disialo and trisialo variants are referred to herein as carbohydrate-deficient transferrin or CDT.

CDT has been found to be an effective marker for alcohol consumption, in particular for detecting and monitoring chronic alcohol consumption, and unlike conventional tests (e.g. GGT or MCV) can be used to screen for heavy alcohol intake in patients with liver disease.

As a result, several diagnostic assays for CDT have been described in patent and scientific literature.

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In US-A-4626355 (Joustra), Pharmacia AB describes a chromatographic assay in which a dilute serum sample is passed over an anionic ion exchange column with the pH and ion content of column and sample balanced to permit asialo, monosialo and disialo CDTs to eluate through in an isocratic procedure while the trisialo ~~and~~ the "normal" tetra and pentasialo variants are retained on the column. The CDT content of the eluate is then determined by competitive immobilization of CDT and radiolabelled-transferrin on an antibody carrying solid phase.

In a recent poster entitled "Rate nephelometric determination of carbohydrate-deficient transferrin", Schellenberg, Martin, Bénard, Circaud and Weill of Laboratoire de Biochimie CHU Trousseau, Tours, Centre Louis Sevestre, La Membrolle sur Choisisle and Beckman France, Gagny, France described a similar isocratic chromatographic separation in which dilute serum is passed through an anionic ion exchange column causing the normal transferrin variants to be retained and allowing CDT to elute through. The eluate is then mixed with polyethyleneglycol and centrifuged, an anti-transferrin antibody is added to the supernatant and the CDT content is assessed by nephelometry.

Heil et al, in *Anaesthetist* 43:447-453(1994) have reported a further isocratic chromatographic procedure for CDT determination. In their procedure a dilute serum sample is passed through an anionic ion exchange resin, again causing normal transferrin variants to be retained while permitting transit of CDT. The CDT content of the eluate is determined by latex particle enhancement of CDT concentration in an immunoturbidimetric assay procedure.

In WO-91/19983 (Sundrehagen), Axis Research AS described an alternative CDT assay in which a dilute serum sample (in which the transferrin variants are bound by labelled (e.g. fluorophore-labelled) antibodies

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or antibody fragments reactive with all variants) is passed through an anionic ion exchange resin and the label concentration in the eluate is determined (e.g. by fluorescence measurement) as a function of eluate fraction. This assay relies upon the elution rates being different for the different variant:labelled binding partner complexes.

All of the assay procedures mentioned above rely upon relatively complex procedures which are not directly applicable to many of the automated multi-task diagnostic machines commonly used by diagnostic laboratories.

We have now found that CDT may be assessed in a straightforward fashion which permits simple measurement techniques such as turbidimetry to be used without needing signal amplification steps such as required by the procedure of Heil et al (supra).

Thus, viewed from one aspect the invention provides a method of assessment of carbohydrate-deficient transferrin in a transferrin containing body fluid, said method comprising the steps of:

- i) obtaining a transferrin containing liquid sample of or derived from a said fluid;
- ii) contacting said sample with a source of iron ions;
- iii) subsequently contacting said sample with an anionic ion exchange resin at a pH such as to cause carbohydrate-deficient transferrin to be retained by said resin;
- iv) subsequently contacting said resin with an eluant serving to release carbohydrate-deficient transferrin into the eluate from said resin;
- v) collecting a volume of said eluate substantially free from tetra- and pentasialo transferrin; and
- vi) assessing the transferrin variant content in said volume of eluate.

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The body fluid used in the assay of the invention may be any transferrin-containing fluid such as synovial fluid or amniotic fluid; however for investigation of alcohol consumption or abuse the fluid will generally be blood. Where this is the case, the liquid sample will preferably be cell-free. Either serum or plasma, i.e. blood derived transferrin containing fluids, are preferred.

The chromatographic technique operates effectively where the transferrin variants are iron ion-loaded and before application to the resin the liquid sample will be contacted with a source of iron ions, e.g. an aqueous Fe(III) solution or a finely divided soluble iron salt. In general, it is desirable although not essential to avoid unnecessary dilution of the sample at this stage. The iron treatment of the sample may simultaneously be used to set the pH of the sample at a level sufficiently high as to cause the CDT variants to be retained by the ion exchange resin. Even though high concentrations of competing anions, such as the plasma chloride ions, can serve to reduce resin immobilization of the transferrins, at sufficiently high pH it is found that the CDTs are nonetheless retained by the resin. The particular pH used will depend upon the nature of the resin, the dilution of the sample, and the competing anion content of the sample (or the resin before sample loading). However in general a pH of at least 6.2, preferably 6.5 to 10, and especially 6.8 to 7.5, e.g. about 7.0, will be used. Thus in effect the pH and the ionic strength together will be such as to cause the CDTs to be retained by the resin.

In a preferred aspect, a blood sample of 10 $\mu$ L to 2.5mL will be used to provide a plasma or serum sample of 4 $\mu$ L to 1mL, preferably 50 to 500 $\mu$ L, especially about 100 to 200 $\mu$ L, which is incubated with an iron containing, relatively low competing anion content buffer, e.g. of pH 7.0. At this stage, there is a

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dilution of up to 1:8, preferably 1:1 to 1:5, especially about 1:2, by volume by the iron-containing buffer solution.

Besides buffering agents such as Tris (tris(hydroxymethyl)aminomethane) and Bis-Tris (bis(2-hydroxyethyl)amino-tris(hydroxymethyl)methane) and iron ion sources (such as  $\text{FeCl}_3$ ), the buffer solution may contain acids such as HCl to set the pH and iron stabilizers such as citrate and maleate. However the concentration of competing anions such as chloride (or cyanide, sulphate etc) should be kept low and iron salts of such anions should not be used in great excess beyond that required to iron-load the transferrins.

The sample, incubated for some minutes with the iron source, e.g. 2 to 30 minutes, preferably 5 to 10 minutes, is then applied to the ion exchange resin.

For this purpose any anionic ion exchange resin which is in charged form may be used. Suitable such materials are the tertiary and quaternary amine resins and in particular materials such as PBE94, DEAE-Sephacrose or Q-Sephacrose obtainable from Pharmacia AB of Sweden or Poros 50 HQ obtainable from Perseptive Inc, USA. Fast flow Q-Sephacrose is especially preferred as it is positively charged over a wide pH range.

The resin will generally be in uniformly packed columns, e.g. filled with a given resin volume, allowed to settle and then tamped down with a low pressure. Above the resin there will preferably be a porous element, such as an inert nylon or polyethylene mesh, filter or frit, which keeps the resin in place and which by virtue of capillary forces serves to prevent air entering the resin after sample or eluants are introduced. In this way the volume of eluate is simply controlled by the volume of eluant added and so careful control of eluant volume automatically gives control of eluate volume and, for the release eluant, thereby gives control of the percentage of any given CDT released into

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the eluate. Preferably the column will have the resin disposed between two porous elements, e.g. porous frits such as the Porex frits available from Porex of Atlanta, Ga, USA. In practice moreover such columns will preferably be provided pre-loaded with a low ionic strength transportation buffer, e.g. a bis-Tris buffer having the same pH as the iron-containing incubation buffer discussed above.

The volume of resin used will depend on the sample volume to be applied to the resin as well as on the nature of the resin. It should be sufficient to absorb substantially all of the transferrin in the sample. With a 200  $\mu$ L serum sample, 1mL resin loaded in 5mm diameter tubes has been found to be adequate. Preferably however 7mm internal diameter tubes loaded with 1.24 cm<sup>3</sup> resin are used.

Before the sample is applied to the resin, any transportation buffer is first allowed to drain off.

Following application of the sample to the resin any eluate is discarded. The resin is then preferably flushed with a low ionic strength eluant (i.e. one which is relatively free of anions such as chloride which compete with the transferrin variants in binding to the resin) of a pH sufficiently high as not to cause transferrin variants to be released, e.g. a Bis-Tris or Tris buffer solution of pH 6.2 or above, preferably 6.25 to 6.5. In this way, unbound material and plasma anions may be flushed from the column. For a 1mL resin column, a flushing volume of 0.3 to 5mL, preferably 2mL, might conveniently be used. Again any eluate is discarded.

The resin is then contacted with an eluant (the release eluant) which serves to release the bound transferrin e.g. by virtue of its low pH and/or high content of competing anions (such as chloride, cyanide, sulphate etc), and a volume of the eluate containing the CDT variants is collected. If, as is preferred, the pH and ionic strength of the release eluant are such as to



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release the "normal" (tetrasialo and pentasialo) transferrins, it is important that the transferrin release be calibrated so that the collected volume is substantially free of such "normal" transferrins. This may readily be done by loading exemplary columns with tetrasialo-transferrin, collecting volume fractions of the eluate and determining at which fraction the tetrasialo variant begins to elute. The volume of release eluant used may thus be set to be the volume which causes the asialo, monosialo and disialo, and preferably also the trisialo, variants to appear in the eluate but which yields an eluate substantially free of the "normal" variants. Resin packed columns should be calibrated in this way on a production batch basis.

The release eluant is preferably administered using a calibrated micropipette to ensure the correct volume is administered. The volume administered should preferably be within 3% of the desired (ie. calibration) volume, more preferably within 1 to 2%.

The release eluant and the CDT loaded resin should preferably be at a temperature within 5C° of the desired (calibration) value, e.g. 25°C, and more preferably within 1C°.

The release eluant will generally have a pH of between 5.0 and 6.8, preferably between 5.5 and 6.5, especially preferably between 5.9 and 6.3, particularly about 6.0. The pH of the release eluant should preferably be within 0.03 pH units of the desired value. The eluant again will preferably be buffered and higher buffer contents than in the incubation and flushing eluants are generally preferred, e.g. about 50mM Bis-Tris. The release eluant thus generates a pH gradient in the resin and causes sequential release of transferrin variants into the eluate thereby enabling the CDT fraction to be selected for calibrated columns. The competing anion content in the release eluant will depend upon the nature of the anion and the resin and

also on the nature and concentration of the buffer. For a release eluant buffered with 50mM Bis-Tris, a chloride content (as NaCl for example) of 1.5 to 25mM, especially 3 to 15mM, more especially 3 to 10mM, particularly 5 to 7mM may conveniently be used in addition to the chloride deriving from the HCl used for pH regulation. The chloride content of the release eluant should preferably be within 1mM of the desired value.

By way of example for 1mL Q-Sepharose columns, it has been found that 3mL of a 50mM Bis-Tris, 6mM NaCl, pH 6.0 release eluant enables the CDT fractions to be isolated in the 2mL eluate collected. Similarly, Example 5 below shows how the asialo to trisialo variants may be eluted from Poros 50 HQ into the 3mL eluate collected.

From the foregoing, it will be clear that the degree of dilution of the CDT variants in the body fluid on passing from the body fluid sample (e.g. blood) to the collected eluate is relatively small. This is one of the important characteristics of the present invention. Thus for example, 500 $\mu$ L blood may yield 200 $\mu$ L serum which in due course yields 2000 $\mu$ L of CDT-containing eluate. In practice, as little as 100  $\mu$ L serum may be sufficient. The volume dilution from serum (or plasma) to eluate will preferably be no more than 50:1 especially preferably no more than 25:1 and particularly no more than 15:1.

The collected eluate containing the CDT variants is then assessed for CDT content. This may be done by any standard immunoassay technique, e.g. an ELISA or radio immunoassay technique. However an important advantage of the assay method of the invention is that it enables assay methods which do not require further separation steps to be used (e.g. nephelometry) and in particular that it allows turbidimetric determination of CDT content. This is important since although nephelometry is in general a more sensitive probe for the production of opacity in a fluid sample than is turbidimetry, the

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technique requires a non-linear optical path for the detection apparatus and thus is not readily adapted for inclusion within existing multi-task light-absorbance determination based diagnostic assay apparatus in which the light path through the sample is linear.

For either turbidimetric or nephelometric CDT determination, opacity will generally be generated by contacting the eluate with an anti-transferrin antibody or antibody fragment, e.g. a rabbit anti-human transferrin antibody such as is commercially available from Dako of Copenhagen, Denmark. The Dako antibodies are specific to transferrin and show no cross reactions with other blood proteins that may be present in the eluate. The quantity of antibody used should of course be optimised against transferrin containing standard samples as opacification arises from the hook effect whereby multiple transferrin binding generates the opacification centres.

As in routine turbidimetric and nephelometric assays, a polymeric opacification enhancer such as polyethyleneglycol is preferably also added to the eluate.

In making the determination of CDT content using such measuring techniques, a kinetic reading mode may of course be used.

Before the nephelometric or turbidimetric determination is made, the eluate, antibody and enhancer should be incubated for a short period, e.g. 5 minutes to an hour, preferably about 10 minutes.

The light used in the determination of opacification should have an appropriate wavelength. In this regard we have found that use of a 405nm filter, or more preferably a 340 nm filter, yields particularly good results.

In general, besides the sample under evaluation, calibration samples with known transferrin contents will also be assessed in the performance of the assay method

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of the invention. Such determinations can be used to plot a calibration curve from which the CDT content of the sample under evaluation may be determined. Preferably calibration samples having transferrin contents of up to 0.05mg/mL (e.g. 0.002, 0.01, 0.02 and 0.03mg/ml) will be used. (These will not of course be passed through the resin columns to separate out the "normal" variants).

Moreover in the assay method of the invention the total transferrin content of the sample will preferably be determined, e.g. with a diluted, non-chromatographed, aliquot using the same assay procedure (i.e. turbidimetry etc). In this way the CDT content may be determined as a percentage of total transferrin (%CDT). %CDT is a more precise marker for alcohol consumption than total CDT, with 6% representing the threshold value.

Viewed from a further aspect, the invention provides a kit for a diagnostic assay according to the invention, said kit comprising:

- an iron ion containing buffered incubation solution having a pH of at least 6.2, preferably about 7.0;

- preferably, a transferrin solution of known concentration and more preferably a set of such solutions having a range of transferrin concentrations;

- an anionic ion exchange resin packed in a container having sample introduction and eluate removal ports;

- preferably, a flushing eluant having a pH and ionic strength insufficient to release transferrin from said resin;

- a release eluant having a pH and ionic strength sufficient to release transferrin from said resin;

- preferably, a light transmitting eluate receiving vessel;

- preferably, an anti-transferrin antibody or antibody fragment; and

- preferably, an opacification enhancer.

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One particular preferred kit comprises simply the incubation solution, the resin (in its container), the flushing eluant and the release eluant.

If desired an automated apparatus may be arranged to receive a transferrin containing body fluid sample, incubate it with an iron-containing incubation solution, apply the incubated solution to an anionic ion exchange resin, optionally flush the resin, apply a release eluant, collect a CDT containing eluate, apply an opacifying anti-transferrin antibody or antibody fragment, and determine CDT content in the eluate. Such apparatus is also deemed to fall within the scope of the invention.

Heretofore there has been doubt as to whether or not the trisialo transferrin variant is or is not indicative of alcohol consumption or abuse. On the one hand Van Eijk et al. in their 1983 paper "The microheterogeneity of human transferrins in biological fluids" in Clin. Chim. Acta 132: 167-171 (1983) stated that "the higher concentration of disialo transferrin in alcoholics has already been reported .. but the CIE [crossed immunoelectric focussing] methods reveal that, also tri-, mono- and asialo-transferrin bands are elevated". On the other hand, however, Pharmacia AB in their patent US-A-4626355 (Joustra) described a technique for separating out the asialo, monosialo and disialo variants from the trisialo, tetrasialo and pentasialo variants by isocratic chromatography, acknowledging that the asialo, monosialo and disialo variants occur at elevated levels in cases where alcohol consumption has been high but stating that "the other isotransferrins, which have no clinical relevance in the context of excessive alcohol consumption, are pentasialo, tetrasialo and trisialo transferrin".

The even more recent patent application WO95/04932 of Biolin Medical similarly identified only the asialo, monosialo and disialo transferrins as markers for

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alcoholism.

As a result it is clear that no significant importance has previously been attached to the trisialo transferrin content in body fluids.

We have now found that the trisialo transferrin content, even in the absence of the other CDT-variants is a strong indication of alcoholism and that in combination with the other CDT variants it yields a significantly clearer distinction between alcoholics and non-drinkers or social drinkers than is possible with an assay of only the asialo, monosialo and disialo variants.

By including some or all of the trisialotransferrin in the CDT fraction assessed, it is possible to use assay techniques (such as turbidimetry for example) that are simpler and more rapid to perform but inherently less precise than prior art techniques while still achieving results with as good or better confidence values.

Thus viewed from a further aspect the invention provides a method of assaying for alcohol consumption, said method comprising assessing a blood derived body fluid sample for its content of a desialo transferrin, characterised in that said desialo transferrin comprises trisialo transferrin, and optionally and preferably one or more of disialo, monosialo and asialo transferrin, particularly preferably all three.

In this method, the assessed desialo transferrin content is preferably determined as a proportion of the total transferrin content (e.g. as % CDT), with 6% being viewed as the threshold value indicative of alcoholism where the assessed desialo transferrin comprises the asialo, monosialo and disialo and 50% of the trisialo variants.

Alternatively viewed the invention provides a method of assaying for alcohol consumption, said method comprising obtaining a first transferrin containing

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liquid sample of or derived from a body fluid and containing tetra- and penta-sialo transferrins;

obtaining from said first sample a second transferrin containing liquid sample, e.g. by elution from a column, said second sample being substantially free from tetra- and pentasialo transferrin and having a transferrin content of at least 1mg/L, preferably at least 2 mg/L; and

turbidimetrically assessing the transferrin content of said second sample.

In particular we have found that including trisialotransferrin in the assay improves discrimination between alcoholics and people with other liver diseases.

In these methods, the desialo transferrin is preferably assessed as a percentage of total transferrin in the sample although, less preferably, it may be assessed as an actual concentration (ie. a mass per unit volume). The assay technique used may be any convenient technique, but techniques as described herein or in US-A-4626355, WO91/19983, WO95/04932, Schellenberg et al. (supra) or Heil et al (supra) are especially preferred.

In the methods of the invention, it is particularly preferred only to assess a fraction (albeit a major fraction for example from 25 to 95%, preferably 30 to 70% especially 40 to 60% and especially preferably about 50%) of the trisialotransferrin, preferably in combination with lower sialylated asialo transferrins, in particular one or more and especially all three of asialo, monosialo and disialo ransferrins.

This partial assessment of the trisialo variant may readily be achieved in the method of the invention by selecting a volume of release eluant which releases only the required fraction of the trisialo variant into the eluate. Apparatus may readily be calibrated as described herein in order to determine what release eluant volume is required to release the desired

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fraction of the trisialo variant.

This method in which a major fraction of the trisialo variant is assessed is particularly advantageous since it avoids potential contamination by the tetrasialo variant (since mini columns of the type described herein generally have lower resolution than HPLC) and since it makes the assay more sensitive to the lower desialylated variants which are generally significantly less abundant than the trisialo variant.

The invention will now be described in further detail with reference to the following Examples and to the accompanying figures in which:

Figure 1 is a typical turbidimetric calibration curve showing absorption at 405 nm as a function of transferrin content;

Figures 2, 3 and 5 are graphical presentations of test results in terms of % CDT for non-alcoholics or total abstainers (NA or TA), social drinkers (SD), alcoholics (AL) and pregnant women (PW), in these figures 0-2-s Trf or 2 sialo indicates that the assessed CDT included the asialo, monosialo and disialo variants, 0-3-s Trf or 2 sialo +100% 3-s indicates that the assessed CDT also included the trisialo variant;

Figure 4 is an HPLC chromatogram measured at 450 nm and showing peaks for the disialo, trisialo, tetrasialo and pentasialo variants;

Figure 6 is a graphical comparison of results for 18 samples tested according to the invention with asialo, monosialo, disialo and 50% trisialo variants being assessed and similarly being tested and assessed by HPLC; and

Figure 7 is a schematic cross-sectional view of a mini-column usable in the methods of the invention.



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EXAMPLE 1Assay KitEquipment

- Tubes (5mm diameter containing 1mL Q-sepharose (Pharmacia) covered with a nylon top filter)
- Pipettes covering volumes from 4 $\mu$ l to 3ml  
Alternatively: multipipettes for volumes 100 $\mu$ l, 200 $\mu$ l, 2ml and 3ml
- Racks (for tubes 75x12mm)
- Microtiter plates
- Reader for microtiter plates, 405nm filter

ReagentsSolution A:

10mM BisTris(bis(2-hydroxyethyl)amino-  
tris(hydroxymethyl)methane)  
1.5mM Sodium Azide  
0.05% Tween 20  
1 M HCl ad pH 7.0  
0.4mM Tris base (Tris(hydroxymethyl)aminomethane)  
0.075mM FeCl<sub>3</sub>  
0.075mM Sodium Citrate  
0.2mM Maleic acid  
deionized H<sub>2</sub>O q.s.

Solution B:

10mM BisTris(bis(2-hydroxyethyl)amino-  
tris(hydroxymethyl)methane)  
3.1mM Sodium Azide  
0.1% Tween 20  
1 M HCl ad pH 6.25  
deionized H<sub>2</sub>O q.s.

Solution C:

50mM BisTris(bis(2-hydroxyethyl)amino-  
tris(hydroxymethyl)methane)  
3.1mM Sodium Azide

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0.05% Tween 20  
1 M HCl ad pH 6.00  
5mM NaCl added  
deionized H<sub>2</sub>O q.s.

Human normal serum (for calibration) containing:  
2.17mg/ml Transferrin

Turbidimetric reagent:

900 $\mu$ l 0.1 M PEG-PBS pH 8.2  
100 $\mu$ l Rabbit anti-human transferrin (Dako)

The 0.1 M PEG-PBS pH 8.2 comprises:

91.8mM Disodiumhydrogenphosphate  
8.3mM Sodiumdihydrogenphosphate \*2H<sub>2</sub>O  
3.1mM Polyethylene glycol  
3.1mM Sodium Azide  
2 M NaOH ad pH 8.2  
deionized H<sub>2</sub>O q.s.

EXAMPLE 2

Alternative Assay Kit

Equipment

- Columns (5mm diameter containing 0.5mL Poros 50 HQ (Perseptive Inc, USA) covered with a nylon top filter)
- Pipettes covering volumes from 4 $\mu$ l to 3ml  
Alternatively: multipipettes for volumes 100 $\mu$ l, 200 $\mu$ l, 2ml and 3ml
- Racks (for tubes 75x12mm)
- Microtiter plates
- Reader for microtiter plates, 405nm filter

Reagents

Solution A:

10mM BisTris(bis(2-hydroxyethyl)amino-  
tris(hydroxymethyl)methane)

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1.5mM Sodium Azide  
0.05% Tween 20  
1 M HCl ad pH 7.0  
0.4mM Tris base (Tris(hydroxymethyl)aminomethane)  
0.15mM FeCl<sub>3</sub>  
0.15mM Sodium Citrate  
0.4mM Maleic acid  
deionized H<sub>2</sub>O q.s.

Solution B:

10mM BisTris(bis(2-hydroxyethyl)amino-  
tris(hydroxymethyl)methane)  
3.1mM Sodium Azide  
0.1% Tween 20  
1 M HCl ad pH 6.25  
deionized H<sub>2</sub>O q.s.

Solution C:

50mM BisTris(bis(2-hydroxyethyl)amino-  
tris(hydroxymethyl)methane)  
3.1mM Sodium Azide  
0.05% Tween 20  
1 M HCl ad pH 6.00  
15mM NaCl added  
deionized H<sub>2</sub>O q.s.

Human normal serum (for calibration) containing:

2.17mg/ml Transferrin

Turbidimetric reagent:

900μl 0.1 M PEG-PBS pH 8.2  
100μl Rabbit anti-human transferrin (Dako)

The 0.1 M PEG-PBS pH 8.2 comprises:

91.8mM Disodiumhydrogenphosphate  
8.3mM Sodiumdihydrogenphosphate \*2H<sub>2</sub>O  
3.1mM Polyethylene glycol

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3.1mM Sodium Azide

2 M NaOH ad pH 8.2deionized H<sub>2</sub>O q.s.EXAMPLE 3Preparation of calibrators and columns

Prepare 4 calibrators using human normal serum. See table 1 for dilutions

TABLE 1 - Preparation of calibrators:

Calibrators (mg/ml)	Human normal serum containing 2.17mg transferrin/ml	Solution C
C1:0.002	100 $\mu$ l C3	900.0 $\mu$ l
C2:0.01	4.6 $\mu$ l	995.4 $\mu$ l
C3:0.02	10.1 $\mu$ l	1089.9 $\mu$ l
C4:0.03	13.8 $\mu$ l	986.2 $\mu$ l

(Calibrator C1 is produced by dilution of calibrator C3 with Solution C of Example 1 or Example 2).

Preparation of columns:

Use one column for each sample to be tested. Elute surplus transport buffer by removing first the top and thereafter the bottom stopper, discard the eluate. Prepared columns should be used within 2 hours.

EXAMPLE 4Sample testing procedure

- Sample procedure
  1. Add 200 $\mu$ l serum to 400 $\mu$ l solution A (of Example 1) in a test tube. Mix.
  2. Incubate for 5-10 minutes at ambient temperature.
- Column separation
  1. All solutions added must elute freely from the column.

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2. Add 500 $\mu$ l incubated sample to a column.
3. Let the sample sink into the top filter before adding 2.0ml of solution B.
4. Let solution B sink into the top filter. Change tubes below columns. Solution eluted up to this point should be discarded. Add 3ml of solution C (of Example 1) to each column. Collect 2ml eluate C.

- Measurement

1. Add 100 $\mu$ l of each calibrator, and 100 $\mu$ l of eluate C from the column separation to separate wells of a microtiter plate.
2. Add 100 $\mu$ l turbidimetric reagent to each well.
3. Incubate for 10 minutes at ambient temperature.
4. Read results using a reader with 405nm filter.
5. Establish a calibration curve using non-linear regression. Figure 1 shows a typical calibration curve.
6. CDT in the serum sample is calculated from the calibration curve.

EXAMPLE 5

Sample testing procedure

- Sample procedure

1. Add 100 $\mu$ l serum to 200 $\mu$ l solution A (of Example 2) in a test tube. Mix.
2. Incubate for 5-10 minutes at ambient temperature.

- Column separation

1. All solutions added must elute freely from the column.
2. Add 200 $\mu$ l incubated sample to a column.
3. Let the sample sink into the top filter before adding 1.0ml of solution B.
4. Let solution B sink into the top filter. Change tubes below columns. Solution eluted up to this

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point should be discarded. Add 3ml of solution C (of Example 2) to each column. Collect 3ml eluate C.

- Measurement

1. Add 100 $\mu$ l of each calibrator, and 100 $\mu$ l of eluate C from the column separation to separate wells of a microtiter plate.
2. Add 100 $\mu$ l turbidimetric reagent to each well.
3. Incubate for 10 minutes at ambient temperature.
4. Read results using a reader with 405nm filter.
5. Establish a calibration curve using non-linear regression. Figure 1 shows a typical calibration curve.
6. CDT in the serum sample is calculated from the calibration curve.

EXAMPLE 6

Comparison of assaying for asialo, monosialo and disialo transferrin as against for asialo, monosialo, disialo and trisialo transferrin

Serum samples from three test groups were analysed for asialo, monosialo, disialo and trisialo transferrin using the HPLC technique described in WO 95/04932. The results presented in Table 2 below and in Figure 2 show asialo + monosialo + disialo (0-2 sTr) and asialo + monosialo + disialo + trisialo (0-3 sTr) contents as percentages of total transferrin. Table 2 also includes the trisialo transferrin percentage content taken on its own (3 sTr).

The first group, the non-drinkers (ND), was of 12 individuals who denied having any alcohol intake. The second group of 26 individuals were social drinkers (SD). 24 individuals having an intake of >60g alcohol on a regular daily basis were placed in the third group, the alcoholics (A).

Table 2

Detected ranges (R) and mean values (M) for 0-2 sTrf, 0-3 sTrf and 3 sTrf expressed as percentages of total transferrin

Group	0-2 sTrf		0-3 sTrf		3 sTrf	
	R	M	R	M	R	M
ND	0.2- 1.8	0.98 (0.50)	2.6- 6.7	4.69 (1.16)	2.4- 4.9	3.71 (0.73)
SD	0.4- 2.7	1.42 (0.54)	2.7- 9.3	5.98 (1.54)	3.1-	4.56 (1.20)
A	1.4-27.6	9.98 (7.13)	10.1-35.6	17.89 (7.36)	7.2 3.3- 11.6	7.9 (1.92)
Overlap ND/SD	Yes		Yes		Yes	
Overlap SD/A	Yes		NO		Yes	
Overlap ND/A	Yes		NO		Yes	

The values in brackets are the standard deviations.

EXAMPLE 7Alternative Assay KitEquipment

- Columns (5mm diameter containing 0.5ml POROS HQ50 (Perseptive Biosystems) covered with a nylon top filter)
- Pipettes covering volumes from 4 $\mu$ l to 3ml  
Alternatively: multipipettes for volumes 100 $\mu$ l, 200 $\mu$ l, 2ml and 3ml
- Racks (for tubes (75x12mm))
- Microtiter plates
- Reader for microtiter plates, 405nm filter

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ReagentsSolution 1

10mM BisTris (bis(2-hydroxyethyl)amino-tris-(hydroxymethyl)methane)  
3.1mM Sodium Azide  
0.05% Tween 20  
1M HCl ad pH 7.0  
0.4mM Tris base (Tris(hydroxymethyl)aminomethane)  
0.075mM FeCl<sub>3</sub>  
0.075mM Sodium Citrate  
0.2mM Maleic acid  
deionized H<sub>2</sub>O q.s.

Solution 2

50mM BisTris (bis(2-hydroxyethyl)amino-tris-(hydroxymethyl)methane)  
3.1mM Sodium Azide  
0.05% Tween 20  
1M HCl ad pH 6.00  
approx 5 mM NaCl added  
deionized H<sub>2</sub>O q.s.

Human normal serum (for calibration) containing:

2.17 mg/ml Transferrin

Turbidimetric reagent

900μl 0.1M PEG-PBS pH 8.2  
100μl Rabbit anti-serum transferrin (Dako)

The 0.1M PEG-PBS pH 8.2 comprises:

91.8mM Disodiumhydrogenphosphate  
8.3mM Sodiumdihydrogenphosphate \*2H<sub>2</sub>O  
3.1mM Polyethylene glycol  
3.1mM Sodium Azide  
2M NaOH ad pH 8.2



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deionized H<sub>2</sub>O q.s.EXAMPLE 8Preparation of calibrators and columns

Prepare 4 calibrators using human normal serum. See table 3 for dilutions

TABLE 3 - Preparation of calibrators:

Calibrators (mg/ml)	Human normal serum containing 2.17 mg transferrin/ml	Solution 2
C1:0.002	100 $\mu$ l C3	900.0 $\mu$ l
C2:0.01	4.6 $\mu$ l	995.4 $\mu$ l
C3:0.02	10.1 $\mu$ l	1089.9 $\mu$ l
C4:0.03	13.8 $\mu$ l	986.2 $\mu$ l

(Calibrator C1 is produced by dilution of calibrator C3 with Solution 2).

Preparation of columns:

Use one column for each sample to be tested. Elute surplus transport buffer by removing first the top and thereafter the bottom stopper, discard and eluate. Prepared columns should be used within 2 hours.

EXAMPLE 9Sample testing procedure

- Sample procedure
  1. Add 100 $\mu$ l serum to 500 $\mu$ l solution 1 in a test tube. Mix.
  2. Incubate for 5-10 minutes at ambient temperature.
- Column separation
  1. All solutions added must elute freely from the column.
  2. Add 500 $\mu$ l incubated sample to a column.

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3. Let the sample sink into the top filter before adding 1.0ml of solution 2.
4. Let solution 2 sink into the top filter. Change tubes below columns. Solution eluted up to this point should be discarded. Add 2.0ml of solution 2 to each column. Collect 2ml eluate 2.

- Measurement

1. Add 200 $\mu$ l of each calibrator, and 200 $\mu$ l of eluate 2 from the column separation to separate wells of a microtiter plate. Read at 405nm.
2. Add 100 $\mu$ l turbidimetric reagent to each well.
3. Incubate for 15 minutes at ambient temperature.
4. Read results using a reader with 405nm filter and subtract the background calculated in step 1.
5. Establish a calibration curve using non-linear regression. Figure 1 shows a typical calibration curve.
6. CDT in the serum sample is calculated from the calibration curve.

EXAMPLE 10

Serum samples from total abstainers (TA), healthy social drinkers (SD) (alcohol consumption below 60 grams/day) and heavy drinkers (AL) (alcohol consumption above 60g/day) were tested using the method of Example 9. The results, which express asialo, mono-sialo, disialo and 50% of trisialo transferrins as a percentage of CDT, are set out in Figure 3. These results correlate well with results obtained by HPLC (see Figure 6) and differentiate well between social and heavy drinkers. There is also a slight difference in % CDT shown between total abstainers and social drinkers. The PW category was for pregnant women where false positives are often found with all methods.

In general a reference limit of 6% CDT for males is found effective for discriminating alcohol abuse.

EXAMPLE 11HPLC Separation

Serum samples were from 17 alcoholics admitted to hospital due to their heavy drinking habits, and all were drinking close up to the time of admittance. Furthermore, serum was sampled from 25 healthy individuals with moderate alcohol consumption habits (<60 grams per day on an average basis) (social drinkers). Furthermore, serum samples of 9 total abstainers were collected.

120 $\mu$ l serum samples are pre-treated with 24 $\mu$ l Fe(III) maleic-citrate (9.25mM) solution for iron saturation. Thereafter 1.3 $\mu$ l solution of 100mg dextran/ml water and 16 $\mu$ l solution of CaCl<sub>2</sub> 147 mg/ml water were added per 120 $\mu$ l serum.

The samples were kept in a refrigerator for 1 hour before they were centrifuged and 100 $\mu$ l of supernatant was diluted to 2.15 ml with water before 2.0ml was applied to a POROS HQ10 (Perseptive Inc, USA) column (0.5cmx5cm) for chromatography.

The transferrin variants were eluted by using a Cl<sup>-</sup> gradient in a 20mM Bis-Tris pH=6.1 buffer system. The 450nm absorption signal from the different variants of transferrin was recorded and the relative amount of each variant was calculated by peak integration.

The clinical information for each sample was correlated to the relative amount of the sum of a-, mono-, and di-sialo-transferrin (%CDT).

Fig. 4 shows the eluting pattern from the HPLC column at 450nm. The dotted line is the Cl<sup>-</sup> gradient. Due to differences in charges the low sialic-acid containing transferrin variants are eluted first. Increasing Cl<sup>-</sup> gradient elutes higher sialic-acid containing transferrin molecules.

After integration and quantitation of the relative transferrin content of the different fractions of transferrins, values from HPLC chromatograms were

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calculated as %CDT, including different relative amounts of the 3-sialotransferrin fractions in this value (30%, 60% and 100%). Figure 5 demonstrates the effect of including different fractions of the 3-sialo-transferrin fraction into the %CDT value, in correlation to the drinking habit subgroups. A clearer separation between the non-drinkers and the alcoholics was achieved when the 3-sialo-transferrin fraction was included, giving better sensitivity and specificity of the assay.

#### EXAMPLE 12 (Best Mode)

##### Alternative Assay Kit

##### Equipment

- Columns (7mm internal diameter) containing 0.5ml POROS HQ50 (Perseptive Biosystems) between polyethylene upper and lower porous frits (Porex, Atlanta, Ga, USA) - columns available from Pierce Company, USA
- Four calibrators prepared as in Example 8
- Pipettes covering volumes from 4 $\mu$ l to 3ml  
Alternatively: multipipettes for volumes 100 $\mu$ l, 200 $\mu$ l, 2ml and 3ml
- Racks (for tubes (75x12mm))
- Microtiter plates
- Reader for microtiter plates, 405nm filter

##### Reagents - Solution 1

10mM BisTris (bis(2-hydroxyethyl)amino-tris-(hydroxymethyl)methane)  
3.1mM Sodium Azide  
0.05% Tween 20  
1M HCl ad pH 7.0  
0.8mM Tris base (Tris(hydroxymethyl)aminomethane)  
0.15mM FeCl<sub>3</sub>  
0.15mM Sodium Citrate

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0.4mM Maleic acid  
deionized H<sub>2</sub>O q.s.

### Solution 2

50mM BisTris (bis(2-hydroxyethyl)amino-tris-  
(hydroxymethyl)methane)  
3.1mM Sodium Azide  
0.05% Tween 20  
1M HCl ad pH 6.00  
approx 5 mM NaCl added  
deionized H<sub>2</sub>O q.s.

### Turbidimetric reagent

900μl 0.3M Tris/PEG pH 7.4  
100μl Rabbit anti-serum transferrin (Dako)

The 0.3M Tris/PEG pH 7.4 comprises:

0.3m Tris. HCl  
6% Polyethylene glycol (PEG 8000)  
3.1mM Sodium Azide  
2M NaOH ad pH 7.4  
deionized H<sub>2</sub>O q.s.

Referring to Figure 7 there is shown a 7mm internal diameter column 1 with sample introduction and eluate removal ports 2 and 3 containing 1.24 cm<sup>3</sup> resin 4 disposed between porous frits 5 and 6.

### Preparation of columns:

Use one column for each sample to be tested. Elute surplus transport buffer by removing first the top and thereafter the bottom stopper, discard and eluate. Prepared columns should be used within 2 hours.

### Sample testing procedure

- Sample procedure

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1. Add 100 $\mu$ l serum to 500 $\mu$ l solution 1 in a test tube. Mix.
2. Incubate for 5-10 minutes at ambient temperature.

- Column separation

1. All solutions added must elute freely from the column.
2. Add 500 $\mu$ l incubated sample to a column.
3. Let the sample sink into the top filter before adding 1.0ml of solution 2.
4. Let solution 2 sink into the top filter. Change tubes below columns. Solution eluted up to this point should be discarded. Add 2.0ml of solution 2 to each column. Collect 2ml eluate 2.

- Measurement

1. Add 200 $\mu$ l of each calibrator, and 200 $\mu$ l of eluate 2 from the column separation to separate wells of a microtiter plate. Read at 405nm.
2. Add 100 $\mu$ l turbidimetric reagent to each well.
3. Incubate for 15 minutes at ambient temperature.
4. Read results using a reader with 405nm filter and subtract the background calculated in step 1.
5. Establish a calibration curve using non-linear regression. Figure 1 shows a typical calibration curve.
6. CDT in the serum sample is calculated from the calibration curve.

- % CDT Determination

1. Take 50  $\mu$ L from the incubated sample from "sample procedure" above and add to 2 mL of solution 2.
2. Take 200  $\mu$ L of the resulting mixture and add to a well of the microtiter plate and measure as in steps 1 to 6 of "measurement" above to give a total transferrin (TT) value.
3. % CDT is calculated as  $[9.76(\text{CDT}/\text{TT}) - 1.73]$

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where CDT and TT are the measured values for CDT and TT respectively.

### EXAMPLE 13

Serum samples from social drinkers (SD) and heavy drinkers (AL) were tested using the method and apparatus of Example 12 and by way of comparison HPLC and the prior art Speciality IEF system (an isoelectric focussing/laser densitometry method).

HPLC analysis was as follows:

#### Instrumentation:

Analytical HPLC separations were performed using a standard FPLC system from Pharmacia Biotech (Uppsala, Sweden).

The monitoring wavelength on the UV-M detector was 450 nm at a full-scale sensitivity of 0.001 Å with a 5 mm pathlength flowcell with mercury optics. A Pharmacia HR 5/5 column (50 mm x 5 mm i.d.) was high-flow packed (7-9 ml/min) with 10 µm particles of Poros HQ 10 (Perseptive Biosystems) to a final gel height of 60 mm.

The column was operated at ambient temperature (20-25°C).

Data/peak evaluations were performed with a Nelson datamodule. Each chromatogram was base-line integrated by a manual method.

#### Reagents:

Analytical-reagent grade chemicals were used. Aqueous solutions were prepared with ultrapure water from a Milli-Q system (Millipore, Milford MA). All buffer/solutions were filtered through a 0.22 µm (pore size) filter and degassed by ultrasonication before use.

FeCl<sub>3</sub>, 6 H<sub>2</sub>O, NaCl, tri-sodium citrate dihydrate, HCl (Titrisol, 1N) and MeOH were purchased from Merck (Darmstadt, F.R.G.). Dextran sulfate and bis-tris were

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purchased from Fluka (Buchs, Switzerland). Trizma-base, maleic acid and  $\text{CaCl}_2$  were purchased from Sigma (St. Louis, MO).

#### Sample preparation:

Serum aliquots were stored for less than three months at  $-20^\circ\text{C}$  before analysis.

150  $\mu\text{l}$  aliquots of serum thawed at room temperature were briefly vortex-mixed with 30  $\mu\text{l}$  of a 9.25 mM  $\text{FeCl}_3$ -tris-maleic acid solution before capping of the tubes and incubation for 30 minutes at room temperature ( $20$ - $25^\circ\text{C}$ ). After incubation, 1.6  $\mu\text{l}$  (100 g/l) dextran sulfate and without delay 7.5  $\mu\text{l}$   $\text{CaCl}_2$  (147 g/l) were added to the serum samples as lipoprotein precipitation mediators.

The samples were refrigerated for 1 hour at  $4$ - $6^\circ\text{C}$  before removal of the precipitated lipoproteins by centrifugation (5000 x g, 15 min.) at  $4$ - $6^\circ\text{C}$ .

130  $\mu\text{l}$  of the clear supernates were poured off and diluted 19.5-fold with water and after a 10 minute delay filtered by a syringe filter (0.22  $\mu\text{m}$  pore size) before injection onto a chromatographic column.

The prepared samples could be stored at  $4$ - $6^\circ\text{C}$  overnight before analysis without any detectable alteration of CDT-content.

#### Chromatographic conditions:

The isoforms of transferrin were separated in a two-buffer system with a multi-step salt gradient elution.

Mobile phase A was 20 mM bis-tris buffer, pH 6.20. Mobile phase B was composed of 20 mM bis-tris buffer, pH 5.60 containing 17.5g/L, NaCl (300 mM). There was strict control of buffer pH versus temperature.

Regeneration/cleaning solution C consisted of methanol and 1N hydrochloric acid (50/50, by vol.). Separation was performed with a flow rate of 2.0 ml/min with a gradient profile as shown in Table 5.

Injection of 2 ml sample was found to be optimal with



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relation to eluant dilution, resolution and signal intensity. With the manual regeneration/cleaning procedure shown in Table 6 it was possible to analyse 100 patients samples before the column back pressure exceeded 4 Mpa. At this point an enzymatic treatment of the column was done according to the instructions of the manufacturer.

Table 5

Time (minutes)	Buffer A, % (by vol.)	Buffer B, % (by vol.)
0.00	100	0
5.00	100	0
14.06	92	8
18.06	92	8
21.09	90	10
24.09	90	10
26.09	86	14
32.09	86	14
33.09	81.5	18.5
45.00	81.5	18.5

Table 6

Buffer A flow	C-injection volume	Run volume
1.0 ml/min	2.0 ml	4 ml, bypass flowcell
1.0 ml/min	2.0 ml	4 ml, through flowcell
4.0 ml/min	-----	4 ml, through flowcell
3.0 ml/min	-----	10 ml, through flowcell
2.0 ml/min	Injection of sample	Waste 3 ml, start prog.

The comparative results are set out in Table 7 below.

Table 7

Sample ID	Specialty's IEF*	Example 13 %CDT**	HPLC		
			% 0-2S	% 3S	% 0-2S + ½ 3S**
SD16	3	3.2	1.26	5.18	3.8
SD24	4	2.2	1.62	3.99	3.6
SD43	6	4.3	1.54	5.40	4.2
SD44	3	1.9	1.71	3.51	3.5
SD45	2	2.9	1.46	4.70	3.8
SD46	1	3.1	1.38	4.50	3.6
SD47	12	3.4	1.93	4.38	4.1
SD48	3	3.8	1.45	4.38	3.6
SD49	5	3.5	1.30	3.96	3.3
SD50	4	3.3	1.39	5.18	4.0
SD68	5	3.9	1.51	5.07	4.0
SD69	22	6.4	2.94	4.69	5.3
SD70	3	3.5	1.26	4.69	3.6
SD71	3	3.8	1.34	5.96	4.3
SD72	6	4.1	1.48	4.76	3.9
SD73	8	3.8	1.97	6.19	5.1
SD74	4	3.1	1.47	3.40	3.2
SD75	5	2.4	1.82	4.04	3.8
SD76	4	3.7	1.60	4.55	3.9
SD77	3	4.7	1.63	7.91	5.6
AL3	5	3.7	2.15	2.71	3.5
AL5	9	6.5			
AL11	8	4.6	2.19	4.13	4.3
AL15	15	7.2	2.76	6.86	6.2
AL30	5	8.4			
AL31	13	7.8	5.30	3.82	7.2
AL36	6	6.7	5.03	2.92	6.5
AL0060	45	14.0	10.24	9.01	14.8
AL0061	44	14.0	10.69	8.62	15.0

AL0073	45	13.8	10.53	5.86	13.5
AL0082	2	6.7	3.67	6.16	6.8
AL0083	33	8.1	5.24	4.18	7.3
AL0084	56	17.9	14.67	5.14	17.2
AL0085	52	18.2	14.45	4.91	16.9
AL0088	32		10.83	5.80	13.7
AL0119	33	10.8	7.81	3.23	9.4
AL0120	32	13.1	9.68	3.14	11.3

\* Threshold value 8  
++ Threshold value 6%

CLAIMS:

1. A method of assessment of carbohydrate-deficient transferrin in a transferrin containing body fluid, said method comprising the steps of:

i) obtaining a transferrin containing liquid sample of or derived from a said fluid;

ii) contacting said sample with a source of iron ions;

iii) subsequently contacting said sample with an anionic ion exchange resin at a pH such as to cause carbohydrate-deficient transferrin to be retained by said resin;

iv) subsequently contacting said resin with an eluant serving to release carbohydrate-deficient transferrin into the eluate from said resin;

v) collecting a volume of said eluate substantially free from tetra- and penta-sialo transferrin; and

vi) assessing the transferrin variant content in said volume of eluate.

2. A method as claimed in claim 1 wherein in step iv) said resin is contacted with an amount of said eluant predetermined to be sufficient only to release from said resin an eluate substantially free of tetra- and penta-sialo transferrin.

3. A method as claimed in claim 2 wherein said amount of said eluant is predetermined to be sufficient to release 30 to 70% of the trisialo transferrin releasable from said resin by said eluant.

4. A method as claimed in claim 2 wherein said amount of said eluant is predetermined to be sufficient to release 40 to 60% of the trisialo transferrin releasable from said resin by said eluant.

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5. A method as claimed in any one of claims 1 to 4 wherein said body fluid is blood.
6. A method as claimed in claim 5 wherein said liquid sample is serum or plasma.
7. A method as claimed in any one of claims 1 to 6 wherein in step ii) said liquid sample is contacted with an aqueous Fe(III) solution.
8. A method as claimed in claim 7 wherein between steps ii) and iii) there is a time interval of 2 to 30 minutes.
9. A method as claimed in any one of claims 1 to 8 wherein the pH of said resin with which said sample is contacted is in the range 6.8 to 7.5.
10. A method as claimed in any one of claims 1 to 9 wherein said resin is a tertiary or quaternary amine resin.
11. A method as claimed in any one of claims 1 to 10 wherein said eluant has a pH of between 5.5 and 6.5.
12. A method as claimed in any one of claims 1 to 11 wherein transferrin variant content is assessed nephelometrically or turbidimetrically.
13. A method as claimed in claim 12 wherein opacity in said eluate is generated by contacting said eluate with an anti-transferrin antibody or antibody fragment.
14. A method as claimed in claim 13 wherein a polymeric opacification enhancer is added to said eluate.
15. A method as claimed in claim 14 wherein between addition of said antibody or antibody fragment and of said enhancer to said eluate and nephelometric or turbidimetric

determination of transferrin variant content there is a time interval of 5 to 60 minutes.

16. A method as claimed in any one of claims 12 to 15 wherein light of wavelength about 405nm or about 340 nm is used in the nephelometric or turbidimetric determination of transferrin variant content.

17. A method as claimed in any one of claims 1 to 16 wherein in step vi) a transferrin variant content of at least 1mg/L in said eluate is assessed turbidimetrically.

18. A method as claimed in any one of claims 1 to 17 wherein the total transferrin content of said sample is also assessed and the carbohydrate deficient transferrin content is determined as a percentage of the total transferrin content.

19. A kit for a diagnostic assay for carbohydrate deficient transferrin, said kit comprising:

- an iron ion containing buffered incubation solution having a pH of at least 6.2;

- optionally, a transferrin solution of known concentration;

- an anionic ion exchange resin packed in a container having sample introduction and eluate removal ports;

- optionally, a flushing eluant having a pH and ionic strength insufficient to release transferrin from said resin;

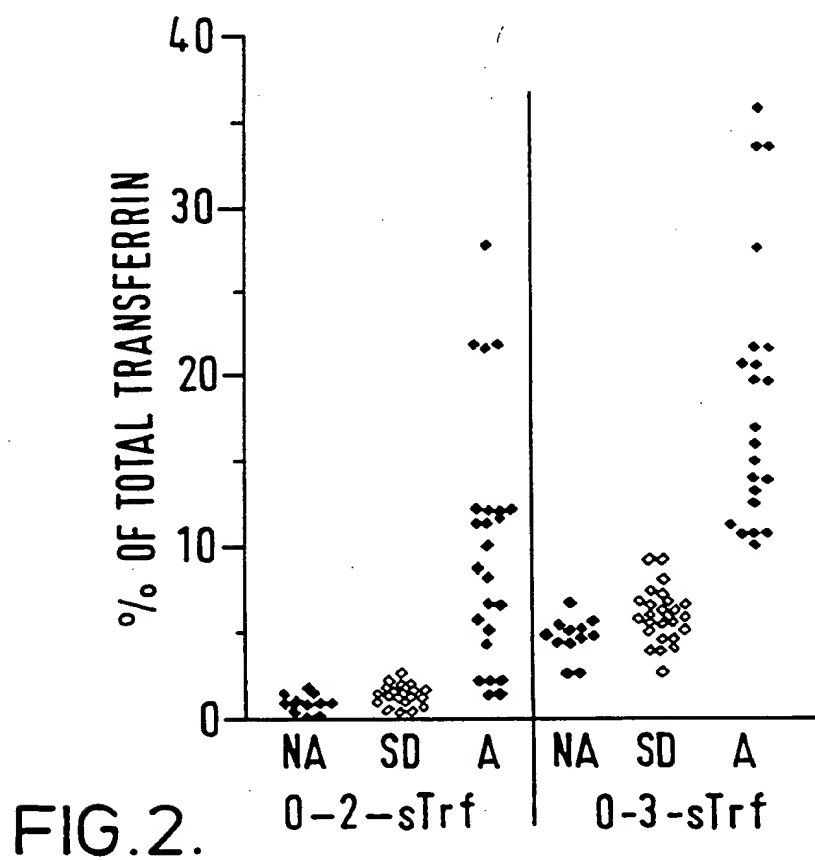
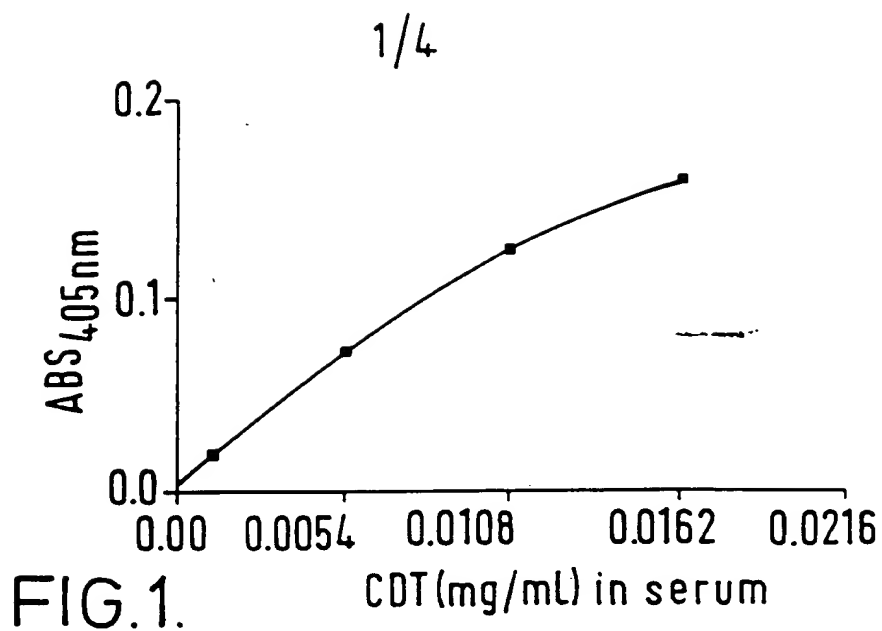
- a release eluant having a pH and ionic strength sufficient to release transferrin from said resin;

- optionally, a light transmitting eluate receiving vessel;

- optionally an anti-transferrin antibody or antibody fragment; and

- optionally, an opacification enhancer.

20. A kit as claimed in claim 19 containing said incubation solution, said resin, said flushing eluant and said release eluant.
21. A kit as claimed in either of claims 19 and 20 wherein disposed adjacent said resin at the sample introduction port end thereof is a porous filter element serving in practice to prevent air entry into said resin following introduction through said introduction port of sample or eluant.
22. A method of assaying for alcohol consumption, said method comprising assessing a blood derived body fluid sample for its content of a desialo transferrin, characterised in that said desialo transferrin comprises trisialo transferrin, and optionally one or more of disialo, monosialo and asialo transferrin.
23. A method as claimed in claim 22 wherein the content of desialo transferrin in said fluid sample is assessed as the proportion <sup>of</sup> the total transferrin content in said sample provided by the asialo, monosialo, disialo and 40 to 60% of the trisialo transferrin variants.
24. A method of assaying for alcohol consumption, said method comprising obtaining a first transferrin containing liquid sample of or derived from a body fluid and containing tetra- and penta-sialo transferrins;  
obtaining from said first sample a second transferrin containing liquid sample, said second sample being substantially free from tetra- and pentasialo transferrin and having a transferrin content of at least 1mg/L; and  
turbidimetrically assessing the transferrin content of said second sample.





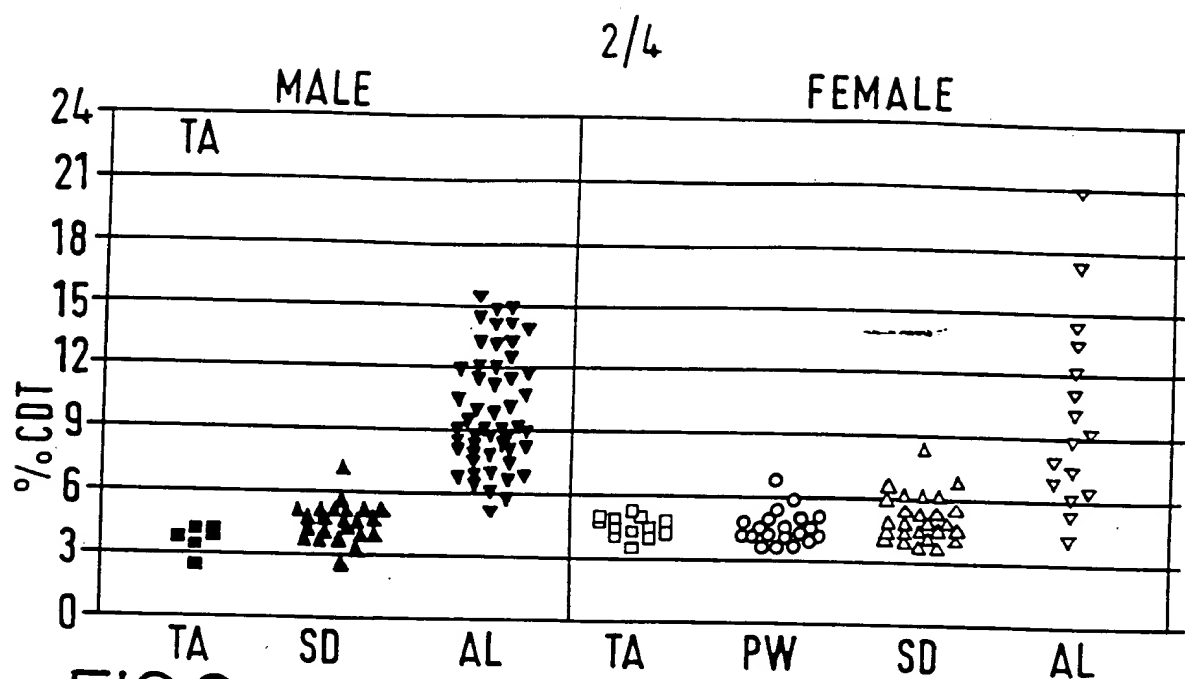


FIG.3.

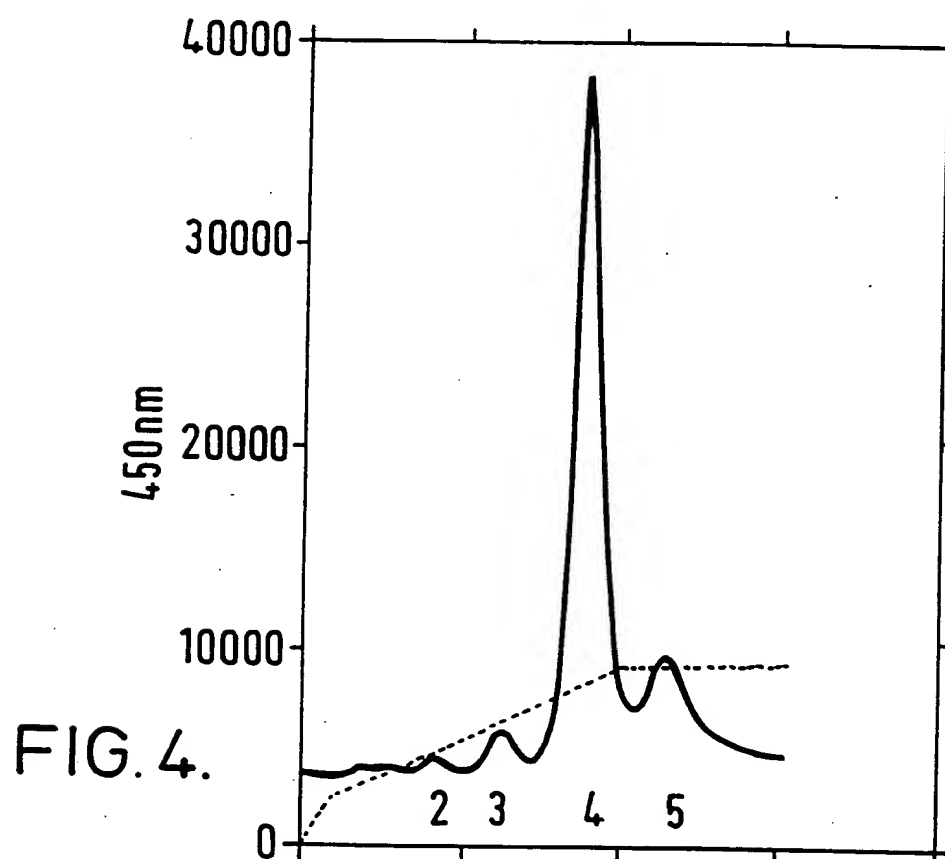
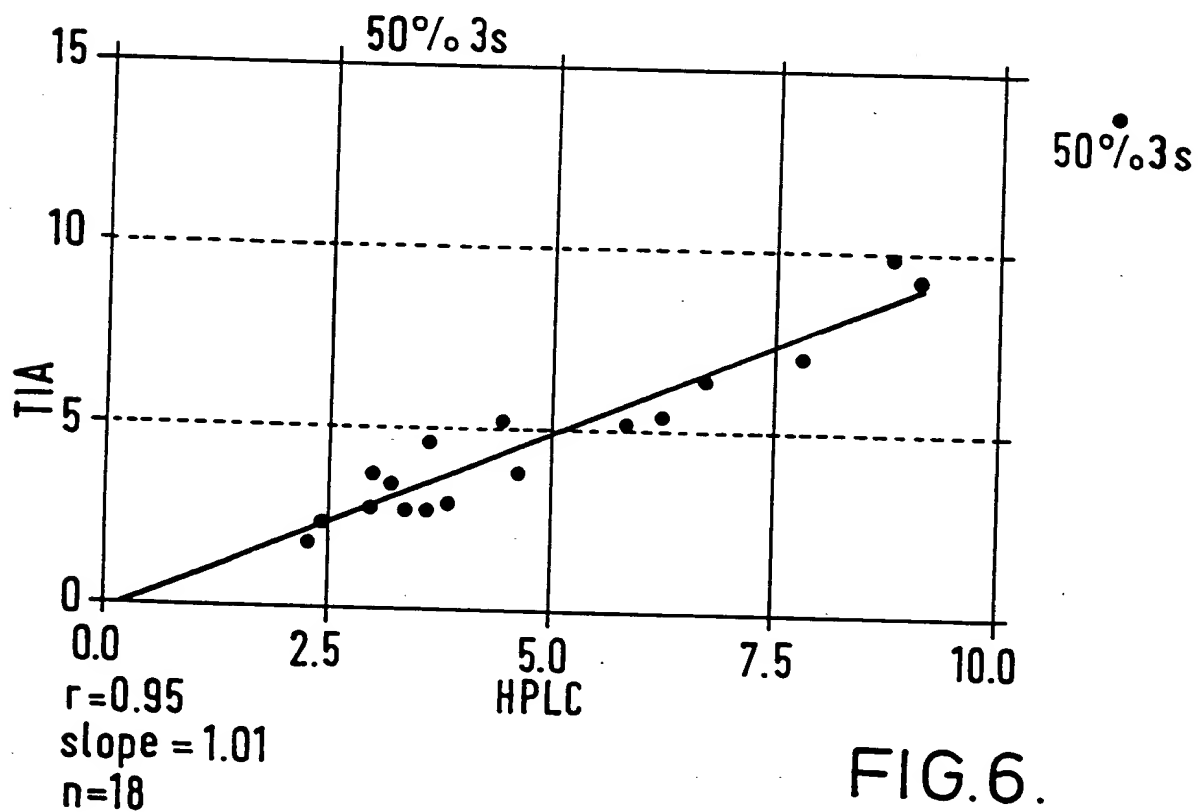
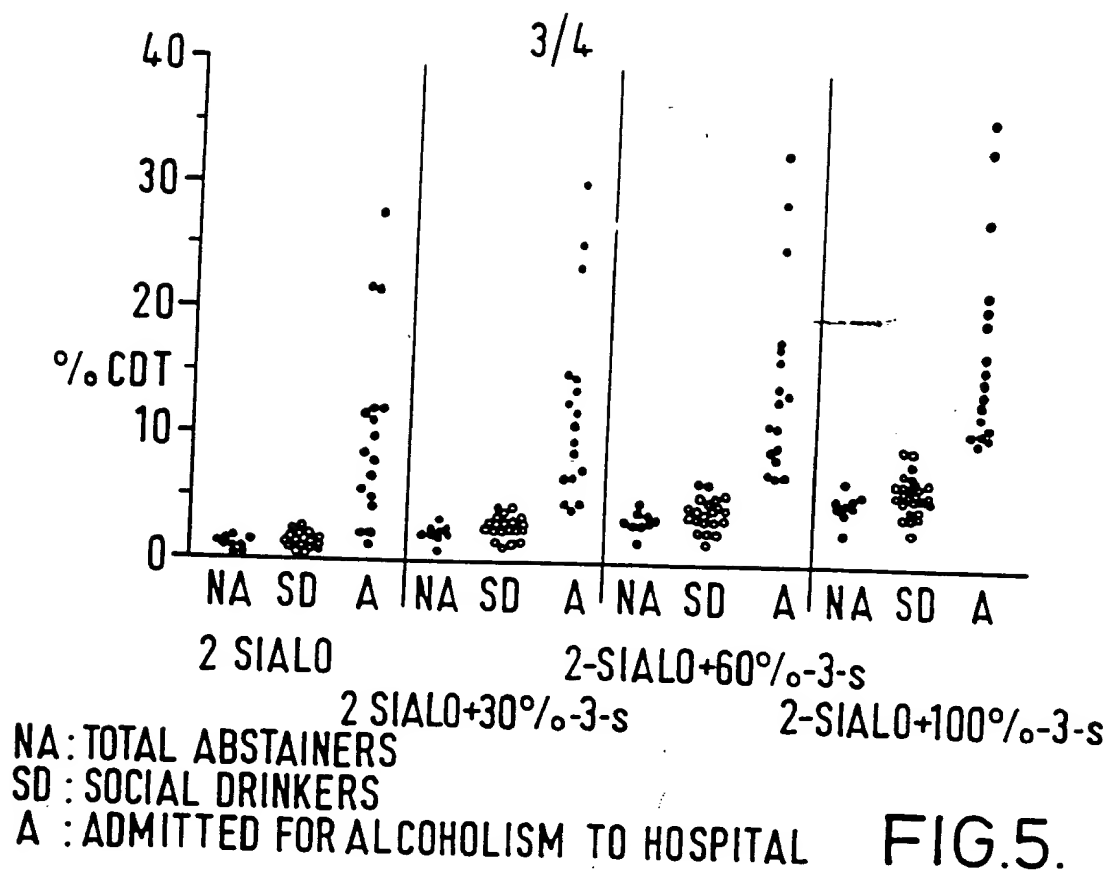


FIG.4.



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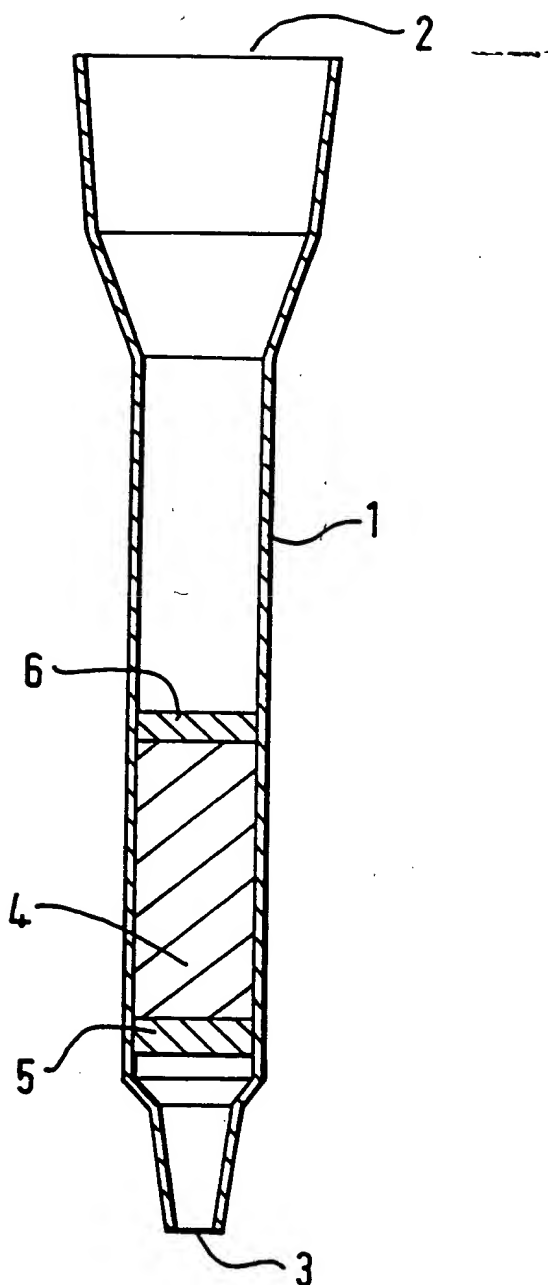


FIG.7.

## INTERNATIONAL SEARCH REPORT

International Application No.

PCT/GB 96/00395

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 6 G01N33/68

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
IPC 6 G01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO,A,95 04932 (BIOLIN MEDICAL AB ;JEPPSSON JAN OLOF (SE)) 16 February 1995 see the whole document	1,5-11, 19-21
Y	see page 2, line 1 - line 17 ---	1-21
Y	WO,A,85 03578 (PHARMACIA AB) 15 August 1985 see page 5, line 14 - page 10; example 2 ---	1-21
X	WO,A,91 19983 (AXIS RESEARCH ;HOLMES MICHAEL JOHN (GB)) 26 December 1991 see the whole document -----	1,5-11

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

12 June 1996

Date of mailing of the international search report

25.06.96

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International Application No

PCT/GB 96/00395

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